# BEST AVAILABLE IMAGES

Defective images within this document are accurate representations of the original documents submitted by the applicant.

Defects in the images may include (but are not limited to):

- BLACK BORDERS
- TEXT CUT OFF AT TOP, BOTTOM OR SIDES
- FADED TEXT
- ILLEGIBLE TEXT
- SKEWED/SLANTED IMAGES
- COLORED PHOTOS
- BLACK OR VERY BLACK AND WHITE DARK PHOTOS
- GRAY SCALE DOCUMENTS

## IMAGES ARE BEST AVAILABLE COPY.

**As rescanning documents *will not* correct images, please do not report the images to the Image Problem Mailbox.**

TS-6372 (US)
DSC:SWT

I hereby certify that this correspondence is being deposited with the United States Postal Service as first class mail in an envelope addressed to Commissioner for Patents, Alexandria, VA 22313-1450, on or before the date shown below.

Del S. Christensen

Date: Dec. 22, 2003

IN THE UNITED STATES PATENT AND TRADEMARK OFFICE

| | |
|---|---|
| In re application of | |
| Robert Andrew Alford et al. | |
| Serial No. 10/621,600 | Group Art Unit: NA |
| Filed July 17, 2003 | Examiner: NA |
| FORGE WELDING PROCESS | Date: December 22, 2003 |

ASSISTANT COMMISSIONER FOR PATENTS
Washington, DC 20231

Sir:

**CLAIM TO PRIORITY**

Applicant(s) reaffirm the claim for the benefit of filing date of the following foreign patent application referred to in Applicant's Declaration:

European Application Serial No. 02255284.8 and 02255282.2 both filed July 29, 2002.

A copy of the application certified by the European Patent Office is enclosed.

Respectfully submitted,

Robert Andrew Alford et al.

By _____
Attorney, Del S. Christensen
Registration No. 33,482
(713) 241-3997

P.O. Box 2463
Houston, Texas 77252-2463

AMDS/TS6372 CTP

TS 6372 USA

Europäisches Patentamt | European Patent Office | Office eur péen des brevets

# Bescheinigung | Certificate | Attestation

Die angehefteten Unterlagen stimmen mit der ursprünglich eingereichten Fassung der auf dem nächsten Blatt bezeichneten europäischen Patentanmeldung überein.

The attached documents are exact copies of the European patent application described on the following page, as originally filed.

Les documents fixés à cette attestation sont conformes à la version initialement déposée de la demande de brevet européen spécifiée à la page suivante.

**Patentanmeldung Nr. | Patent application No. | Demande de brevet n°**

02255284.8

Der Präsident des Europäischen Patentamts;
Im Auftrag

For the President of the European Patent Office

Le Président de l'Office européen des brevets
p.o.

**R C van Dijk**

Anmeldung Nr:
Application no.: 02255284.8
Demande no:

Anmeldetag:
Date of filing: 29.07.02
Date de dépôt:

Anmelder/Applicant(s)/Demandeur(s):

SHELL INTERNATIONALE RESEARCH
MAATSCHAPPIJ B.V.
Carel van Bylandtlaan 30
2596 HR Den Haag
PAYS-BAS

Bezeichnung der Erfindung/Title of the invention/Titre de l'invention:
(Falls die Bezeichnung der Erfindung nicht angegeben ist, siehe Beschreibung.
If no title is shown please refer to the description.
Si aucun titre n'est indiqué se referer à la description.)

Improved forge welding process

In Anspruch genommene Priorität(en) / Priority(ies) claimed /Priorité(s) revendiquée(s)
Staat/Tag/Aktenzeichen/State/Date/File no./Pays/Date/Numéro de dépôt:

Internationale Patentklassifikation/International Patent Classification/
Classification internationale des brevets:

B23K20/00

Am Anmeldetag benannte Vertragstaaten/Contracting states designated at date of filing/Etats contractants désignées lors du dépôt:

AT BE BG CH CY CZ DE DK EE ES FI FR GB GR IE IT LI LU MC NL PT SE SK TR

TS 6372 EPC

Peb

# IMPROVED FORGE WELDING PROCESS

## Background of the Invention

The invention relates to an improved forge welding process.

Forge welding involves circumferential heating of the pipe ends that are to be joined and subsequently pressing the pipe ends together to form a metallurgical bond.

A large variety of heating technologies may be used to make the pipe ends hot enough such that the metallurgical bond can be made. The heating techniques may involve electric, electromagnetic, induction, infrared, arcing and/or friction heating or combinations of these and other heating methods.

When used in this specification the term forge welding is intended to encompass all techniques which involve circumferential heating of pipe ends and subsequent metallurgical bonding of the heated pipe ends, including welding techniques that are generally known as fusion or diffusion welding, friction welding, flash welding and/or butt welding.

It is known from US patents 4,566,625 ; 4,736,084 ; 4,669,650 and 5,721,413 issued to Per H. Moe that it may be beneficial to flush the pipe ends just before and during the forge welding operation with a reducing flushing gas, such as hydrogen or carbon monoxide, such that surface oxides are removed from the heated pipe ends and a metallurgical bond with a minimal amount of irregularities is obtained. It is also known from US patents 2,719,207 and 4,728,760 to use

non explosive gas mixtures comprising about 95% by volume of a substantially insert gas, such as argon, nitrogen and/or helium, and about 5% by volume of a reducing gas, such as hydrogen and/or carbon monoxide for flash welding and induction butt welding.

Experiments have shown that forge welding techniques are capable to generate high quality metallurgical bonds between the tubular ends, in particular if the pipe ends are flushed with a reducing gas mixture during the welding operation, but that the red-hot pipe ends are generally deformed such that upsets are formed in the region of the welding zone.

For obtaining a high quality forge weld joint it is required to keep the tubular ends fully aligned with the end faces parallel to each other at a well-defined spacing of a few millimeters only during the heat-up phase and to terminate the heat-up if the pipe ends have reached a preset temperature and to forge the tubular ends for a well-defined length and to cool them down quickly at a well defined cooling rate, which steps are difficult to accomplish at many sites where pipe ends are welded together, such as on oil rigs, pipelaying barges and many on-land sites where underground or above-ground pipelines are to be installed.

It is an object of the present invention to provide an improved method for forge welding of tubulars, in particular well and/or other oil field tubulars such that a high quality metallurgical bond is obtained and the welding process can be carried out in only a few minutes.

**Summary of the Invention**

The improved method of forge welding tubulars according to the invention comprises heating the tubulars ends to be joined in a welding chamber to a predetermined

temperature while the heated tubular ends are maintained substantially aligned and parallel relative to each other and at a small spacing, whereupon the heated tubular ends are pressed against each other while a reducing shield gas is injected into the chamber to flush oxides from the tubular ends, in order to form a forge weld with a minimal amount of oxide inclusions and other irregularities, wherein during at least part of the heat up, forge welding and/or cool down steps the positions of the end surfaces are monitored by a number of circumferentially spaced cameras which are coupled to a pyrometric and position monitoring system which automatically adjusts the position of the tubular ends relative to each other and the heat supplied to the end faces during the heating step until the pyrometric monitoring system indicates that the tubular end faces have reached a predetermined temperature, whereupon the end faces are moved towards each other along a distance which exceeds the spacing monitored between the end faces during the heating step with a selected extra distance, such that the end faces are firmly pressed against each other and the amount of external and/or internal upset of the tubular ends in the welding zone is limited to an acceptable level.

Preferably a set of at least three cameras is arranged at regular circumferential spacing around the welding zone and the position monitoring system controls a gripping assembly which holds at least one of the tubulars such that during the heat up phase a spacing of only a few millimeters is maintained between the heated tubular end faces and the tubular ends move towards each other during the forge welding step over a distance which exceeds said spacing by less than a few millimeters.

It is also preferred that, at least for part of the forge welding operation, a non-explosive flush gas mixture of a substantially inert gas and a reducing gas is injected into the welding chamber. A preferred non-explosive flush gas mixture comprises more than 90% by volume of nitrogen, argon and/or helium and more than 2 % by volume of hydrogen.

**Description of a preferred embodiment**

The invention will be described in more detail and by way of example with reference to the accompanying Fig.1, which provides a schematic outline of the automated forge welding method according to the invention.

As shown in Fig.1 the positions of the tubular ends 3 and 4 that are to be forge welded together are monitored by cameras 1 and 2 which are coupled to a camera signal processor 5 which automatically controls a gripping assembly 6, such that the spacing S between the heated tubular ends 3 and 4 is well defined during the heat up phase and the tubular ends are moved towards each other when a pyrometric control unit indicates that the tubular ends have reached a predetermined minimum and/or maximum temperature along at least a substantial part of the circumference thereof , whereupon the gripping assembly is activated to move the tubular ends 3 and 4 towards each other over a predetermined distance which exceeds said spacing S with an additional distance D of less than a few millimeters, such that a forge weld is obtained of a substantially equal and high quality over the entire circumference of the forge welded ends and only minimal external and/or internal upsets of the forge welded ends is created , which upsets do not have to be removed afterwards by grinding, milling or machining.

# C L A I M S

1. A method of forge welding tubulars, wherein the tubular ends to be joined are heated in a welding chamber to a predetermined temperature while the heated tubular ends are maintained substantially aligned and parallel relative to each other and at a small spacing, whereupon the heated tubular ends are pressed against each other while a reducing shield gas is injected into the chamber to remove oxides from the tubular end in order to form a forge weld with a minimal amount of oxide inclusions and other irregularities, wherein during at least part of the heat up, forge welding and/or cool down steps the positions of the end surfaces are monitored by a number of circumferentially spaced cameras which are coupled to a pyrometric and position monitoring system which automatically adjusts the position of the tubular ends relative to each other and the heat supplied to the end faces during the heating step until the pyrometric monitoring system indicates that the tubular end faces have reached a predetermined temperature, whereupon the end faces are moved towards each other along a distance which exceeds the spacing monitored between the end faces during the heating step with a selected extra distance, such that the end faces are firmly pressed against each other and the amount of external and/or internal upset of the tubular ends in the welding zone is limited to an acceptable level.

2. The method of claim 1, wherein a set of at least three cameras is arranged at regular circumferential spacing around the welding zone and the position

monitoring system controls a gripping assembly which holds at least one of the tubulars such that during the heat up phase a spacing of only a few millimeters is maintained between the heated tubular end faces and the tubular ends moved towards each other during the forge welding step over a distance which exceeds said spacing by less than a few millimeters.

3. The method of claim 1, wherein during at least part of the forge welding operation a non-explosive flush gas mixture of a substantially inert gas and a reducing gas is injected into the welding chamber.

4. The method of claim 3, wherein the non-explosive flush gas mixture comprises more than 90% by volume of nitrogen, argon and/or helium and more than 2 % by volume of hydrogen.

5. The method of any preceding claim, wherein the joined tubulars are well and/or oilfield tubulars which are joined together by forge welding at or near a drilling rig, offshore platform, pipelaying unit or a similar drilling and/or oil and/or gas production facility.

## A B S T R A C T

IMPROVED FORGE WELDING PROCESS

An automated method for forge welding tubulars comprising heating the tubular end to be joined in a welding chamber to a predetermined temperature while the heated tubular ends are maintained substantially aligned and parallel relative to each other and at a small spacing, whereupon the heated tubular ends are pressed against each other while a reducing shield gas is injected into the chamber to reduce oxides from the tubular end to form a forge weld with a minimal amount of oxide inclusions and other irregularities, wherein during at least part of the heat up, forge welding and/or cool down steps the positions of the end surfaces are monitored by a number of circumferentially spaced cameras which are coupled to a pyrometric and position monitoring system which automatically adjusts the position of the tubular ends relative to each other and the heat supplied to the end faces during the heating step until the pyrometric monitoring system indicates that the tubular end faces have reached a predetermined temperature, whereupon the end faces are moved towards each other along a distance which exceeds the spacing monitored between the end faces during the heating step with a selected extra distance, such that the end faces are firmly pressed against each other and the amount of external and/or internal upset of the tubular ends in the welding zone is limited to an acceptable level.

(Fig.1)


BS1/TS6372PD

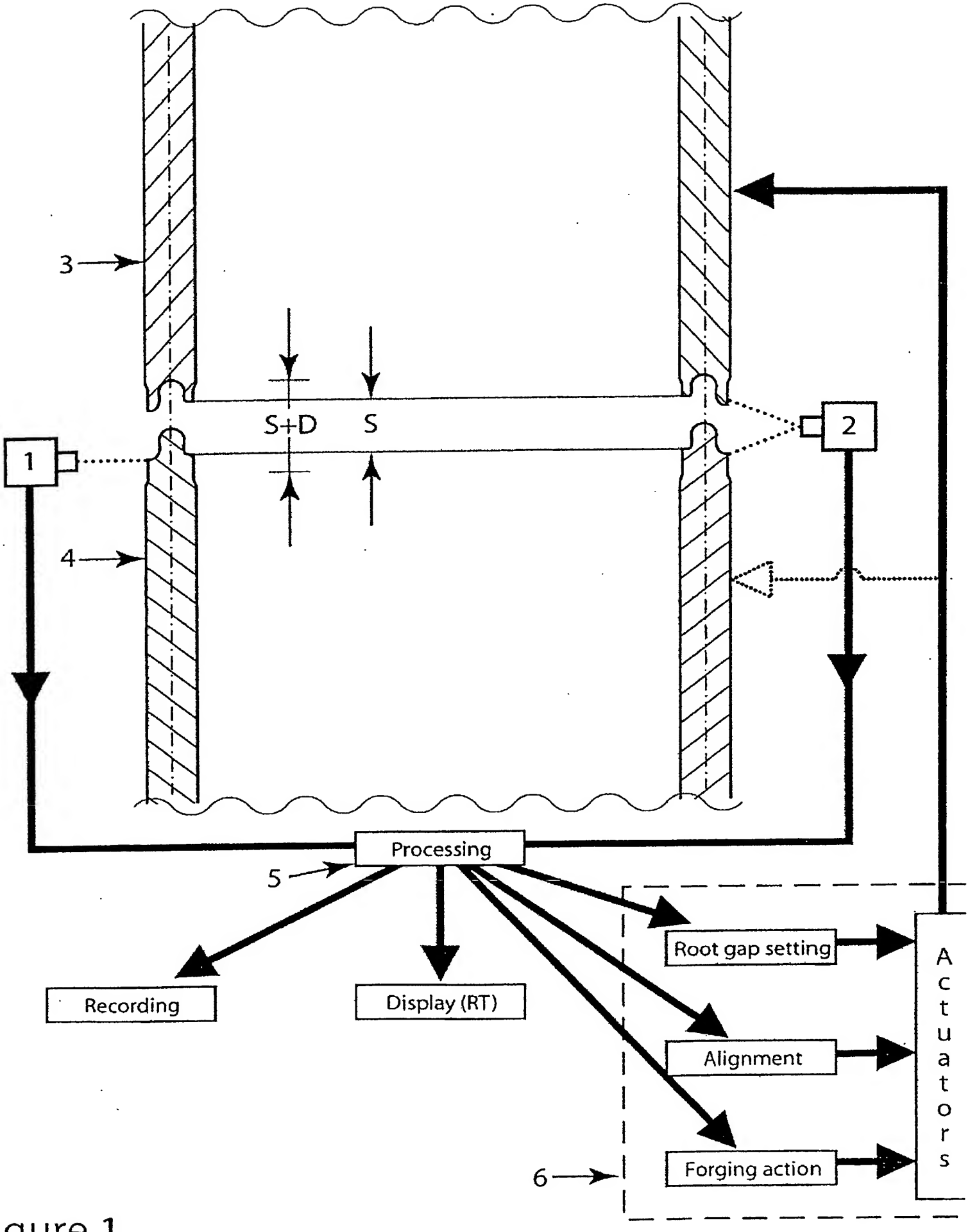
3
S+D
S
1
2
4
Processing
5
Recording
Display (RT)
Root gap setting
Alignment
Forging action
6
Actuators

Figure 1